



PCT/GB 2003 / 0 0 2 7 7 5

10/51934



INVESTOR IN PEOPLE

The Patent Office

Concept House

Cardiff Road

Newport

South Wales

NP10 8QQ WIPO

REC'D 08 AUG 2003

PCT

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.



Signed

*P. Mahoney*

Dated

25 July 2003

**PRIORITY  
DOCUMENT**

SUBMITTED OR TRANSMITTED IN  
COMPLIANCE WITH RULE 17.1(a) OR (b)

BEST AVAILABLE COPY

Patents Form 1/77 THE PATENT OFFICE

Patents Act 1977  
(Rule 16)

28 JUN 2002

RECEIVED BY FAX

28JUN02 E729547-1 003841  
P01/7700 0.00-0215003.5**Request for grant of a patent**

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road  
Newport  
South Wales  
NP10 8QQ

1. Your reference

518

2. Patent application number

(The Patent Office will fill in this part)

0215003.5

28 JUN 2002

3. Full name, address and postcode of the or of each applicant (underline all surnames)

GORBUNOV, BORIS ZACHARY  
20 KINGS PARK  
CANTERBURY  
KENT CT1 1QH  
GB

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

710331.0002

4. Title of the invention

PARTICLE COLLECTOR

5. Name of your agent (if you have one)

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

COHEN, ALAN NICOL  
2 GROVE PLACE  
TATSFIELD  
Nr. WESTERHAM  
KENT  
TN16 2BB

Patents ADP number (if you know it)

6963557001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number  
(if you know it)Date of filing  
(day / month / year)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
(day / month / year)

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

NO

a) any applicant named in part 3 is not an inventor, or  
b) there is an inventor who is not named as an applicant, orc) any named applicant is a corporate body.  
See note (d))

Patents Form 1/77

9040392 28 Jun 02 03:25

## Patents Form 1/77

- Enter the number of sheets for any of the following items you are filing with this form.  
Do not count copies of the same document

Continuation sheets of this form

Description

Claim(s)

Abstract

Drawing(s)

2  
8 /  
4 /  
1 /  
2 only

CF

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

Request for preliminary examination and search (Patents Form 9/77)

Request for substantive examination (Patents Form 10/77)

Any other documents  
(please specify)

11.

I/We request the grant of a patent on the basis of this application.

Signature



Date

28/06/02

12. Name and daytime telephone number of person to contact in the United Kingdom

A. N. Cohen

01959 577172

**Warning**

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

**Notes**

- If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.
- Write your answers in capital letters using black ink or you may type them.
- If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.
- If you have answered 'Yes' Patents Form 7/77 will need to be filed.
- Once you have filled in the form you must remember to sign and date it.
- For details of the fee and ways to pay please contact the Patent Office.

Patents Form 1/77

0040392:28 Jun 02:03:25

## Patents Form 1/77

Patents Act 1977  
(Rule 16)

THE PATENT OFFICE  
A  
28 JUN 2002  
RECEIVED BY FAX



## Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road  
Newport  
South Wales  
NP10 8QQ

## 1. Your reference

518

## 2. Patent application number

(The Patent Office will fill in this part)

0215003.5

## 3. Full name, address and postcode of the or of each applicant (underline all surnames)

28 JUN 2002

PRIEST. NICHOLAS DERHAM  
SANDACRES  
GAINFIELD  
BUCKLAND  
OXFORDSHIRE  
SN7 8QQ  
GB

Patents ADP number (If you know it)

If the applicant is a corporate body, give the  
country/state of its incorporation

7487788001

## 4. Title of the invention

## 5. Name of your agent (if you have one)

"Address for service" in the United Kingdom  
to which all correspondence should be sent  
(including the postcode)

Patents ADP number (if you know it)

## 6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number  
(if you know it)

Date of filing  
(day / month / year)

## 7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
(day / month / year)

## 8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

- a) any applicant named in part 3 is not an inventor, or
  - b) there is an inventor who is not named as an applicant, or
  - c) any named applicant is a corporate body.
- See note (d))

Patents Form 1/77 THE PATENT OFFICE  
 A  
 28 JUN 2002  
 RECEIVED BY FAX

Patents Act 1977  
 (Rule 16)



# Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road  
 Newport  
 South Wales  
 NP10 8QQ

## 1. Your reference

518

## 2. Patent application number

(The Patent Office will fill in this part)

0215003.5

28 JUN 2002

## 3. Full name, address and postcode of the or of each applicant (underline all surnames)

MIDDLESEX UNIVERSITY VENTURES LTD  
 BOUNDS GREEN ROAD  
 LONDON  
 N11 2NQ  
 GB

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

8412900001

II

## 4. Title of the invention

## 5. Name of your agent (if you have one)

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

Patents ADP number (if you know it)

## 6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number  
 (if you know it)

Date of filing  
 (day / month / year)

## 7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
 (day / month / year)

## 8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

- a) any applicant named in part 3 is not an inventor, or
  - b) there is an inventor who is not named as an applicant, or
  - c) any named applicant is a corporate body.
- See note (d))

Patents Form 1/77

0040392 28 JUN 02 03 25

- 1 -

## Particle Collector

The present invention relates to a method and apparatus for collecting particles suspended in a fluid.

5

Collecting the particulate matter suspended in a fluid, e.g. air, is an important stage of air quality assessment, atmospheric science and aerosol technology and particles collected from a fluid are analysed by various chemical and physical methods for particulate matter characterisation.

10

There are two methods of particle characterisation (i) bulk analysis and (ii) size selective analysis. The later usually involves describing the particle size distributions and so the size selective collection of particles is an important stage in their characterisation and the present invention relates to the size selection of particles.

15

A known method of characterising aerosol particles size distributions is based on the deposition of particles onto substrates in a cascade impactor and further analysis of the deposits (e.g. by gravimetric or chemical analysis). In a cascade impactor particles of different sizes are collected onto different substrates due to the difference in their inertia. The selectivity of deposition is achieved by means of a number of air jets with specific aerodynamic characteristics. Each stage of an impactor has a different jet facing the substrate where particles are collected. Thus, an impactor enables a set of mass concentrations in various size ranges (size sections) to be obtained.

20

Usually a cascade impactor is used to collect particles larger than 0.3  $\mu\text{m}$ . This method has a limitation and it is very difficult to apply it to particles smaller than 0.3  $\mu\text{m}$ .

- 2 -

Another method relevant to obtaining aerosol size distributions is the deposition of aerosol particles onto a fibre or membrane filter. In this method a size selective inlet is often used to remove particles larger than certain size, e.g. 10  $\mu\text{m}$ . All particles passed through the inlet are collected onto a filter and are analysed later. This method is simpler to use than cascade impactors. Various size selective inlets are used along with a filter to sample the mass fraction of an aerosol, for instance  $\text{PM}_{10}$ ,  $\text{PM}_{2.5}$  or  $\text{PM}_1$  (where the figure indicates the cut off aerodynamic diameter of the inlet). The filter method enables a wide range of particles to be collected, even particles smaller than 0.3  $\mu\text{m}$ , however it has a limited capability for obtaining information about particle sizes and, in particular, the major drawback of this method is its inability to deliver the size resolved information so size distributions of the particulate matter cannot be obtained with this technique.

We have devised an improved method and apparatus for collecting particles from a fluid.

According to the invention there is provided a method for selective deposition of suspended particles from a fluid which method comprises passing the fluid sequentially over a first collector adapted to collect larger particles and then over a second collector adapted to collect smaller particles, which second collector comprises a chamber in which there is at least one net or another material containing fibres placed across the chamber.

The invention also provides a particle collector for collecting and sampling particles in a fluid which comprises sequentially (i) an inlet (ii) a first collector adapted to collect larger particles and (iii) a second collector adapted to collect smaller particles comprising a chamber in which there is at least one net placed across the chamber and a flows means able to sustain a flow of fluid sequentially through the inlet, first collector and second collector.

30

- 3 -

The nets can be any structure which has the equivalent effect to nets e.g. can be woven, knitted or formed of fibres so that the effect is similar to nets in removing particles for example they can also be can be rigid or semi rigid.

- 5 By larger particles is meant particles larger than those collected in the second collector in general this will mean particles of size of above about 0.3  $\mu\text{m}$ .

There optionally can be further collecting media through which the fluid subsequently will flow in use.

10

Preferably the first collector comprises a cascade impactor or a sedimentation cell e.g. containing set of parallel horizontal partitions.

15

The second collection collector can comprise at least one and preferably at least two nets of different mesh sizes mounted within a container, so that the fluid passes sequentially through the nets. There can be three, four, five or more nets.

20

Thus, particles of different sizes are collected on different nets. The first net facing the fluid flow collects the smallest particles (e.g. from 1 to 10 nm). The particles larger than 10 nm penetrate through the first net. The second net collects the particles in the size range from 10 to 30 nm. The particles larger than 30 nm but smaller than 100 nm penetrate through the second net and they are collected by the third net; particles greater than 100 nm are collected by the fourth net.

25

The nets can be either identical or different. Different nets can be used to increase the size range of particles to be deposited. For example the first net have a mesh opening 120  $\mu\text{m}$ ; the second net can have a mesh opening of 40  $\mu\text{m}$ ; the third net can have a mesh opening of 20  $\mu\text{m}$  and the fourth net can have a mesh opening of 10  $\mu\text{m}$ .

- 4 -

The net sampling is applicable only for sub-micron size particles, for instance for particles smaller than about 0.3  $\mu\text{m}$ . so the first collecting collector preferably collects particles above this size.

- 5 When a sedimentation cell with a plurality of partitions is used as the first collector the particles are separated due to gravitational settling onto the partitions and can be analysed later. The sedimentation of particles depends on their size. Thus analysing the different parts of the pile of partitions makes it possible to obtain additional information about the size distribution of the particles.

10

Preferably the collection of particles on the net(s) takes place at controlled humidity and preferably there is a humidity control unit is incorporated between the inlet and the large particle collector.

- 15 The invention is suitable for use with aerosols and, in use with an aerosol the aerosol particles are introduced into the inlet and after that go into the first section of the first collector (e.g. the first stage of the cascade impactor). A fraction of particles of the higher collection ability is collected by the first stage. The rest of particles goes further with the flow and is deposited onto the next stages. Every stage collects
- 20 particles of certain sizes. After passing all the stages of the cascade impactor, the flow goes into the net sampler where smaller particles are deposited according to their efficiency. A fraction of particles of the higher collection ability is collected by the first net. The rest of particles goes further and is collected by the next nets.

- 25 The invention is illustrated in the accompanying drawings in which

Fig. 1 shows an existing collector

Fig. 2 shows schematically a net collector which can be used

Fig. 3 shows schematically as simple collector according to the invention and

- 30 Fig. 4 shows schematically a more detailed collector

- 5 -

Referring to fig. 1 existing collectors for use with aerosols comprise a size selective preseparator (21) (e.g. a cyclone with 10  $\mu\text{m}$  cut off aerodynamic size); inlet (22); filter (23) and outlet (24).

5

In use the aerosol passes through cyclone preseparator (21) which collects particles above 10  $\mu\text{m}$ . and the aerosol particles pass through inlet (22) then deposited onto a fibre or membrane filter (23) and the air then passes out through outlet (24). All the particles passed through the inlet are collected onto the filter and are analysed later.

10

Referring to fig. 2 there is a container (16) with inlet (11); nets (12) and outlet (13). In use particles of different sizes are collected on different nets. The first net faces the flow and collects the smallest particles (e.g. from 1 to 10 nm). The particles larger than 10 nm penetrate through the first net. The second net collects the particles in the size range from 10 to 30 nm. The particles larger than 30 nm but smaller than 100 nm penetrate through the second net and they are collected by the third net. Particles greater than 100 nm are collected by the fourth net.

15

Referring to fig. 3 there is a sedimentation cell (17) containing horizontal partitions (15) and inlets and outlets (14), (11), and (13).

20

In use the particles are separated in separator (17) due to gravitational settling onto the partitions (15) and these particles can be analysed later. The sedimentation of particles depends on their size. Thus analysing the different parts of the pile of partitions makes it possible to obtain additional information about the size distribution of aerosol particles. After leaving (17) the fluid passes through inlet (11) to net separator (16) which functions as described in fig. 2.

25

Referring to fig. 4 This illustrates a wide range aerosol sampler WRAS designed to collect selectively aerosol particles in a wide range of sizes from 1nm to 30  $\mu\text{m}$

30

- 6 -

aerodynamic diameter under a constant controlled humidity. The flow rate is from 1 to 30 l/min and the sampling humidity (inside the sampling system) is from 30 to 95%.

- 5 The collector and sampling system consists of a net sampler (1); humidity control unit (2); cascade impactor (3) aerosol chamber (4); inlet (5); flow meter (6); saturator (7); pump (8) and outlet (9) with aerosol filter.

- 10 In use this system provides sampling under a constant humidity that could be set using the humidity control unit button on humidity control unit (2), aerosol enters the saturator (7) through the inlet (5), after the saturator the aerosol goes into the aerosol chamber (4) where water vapour condenses onto particles. The chamber (4) is connected to the humidity control unit (2). If humidity is lower than required the heater in the saturator is turned on by the humidity controller. It gives more water  
15 vapour and humidity is increased.

- After the humidity control unit (2) aerosol enters the cascade impactor (3) where particles larger than 0.25  $\mu\text{m}$  are collected onto impactor slides: Microscope Slides (Size 76 x 26 mm; Thickness 1.0 -1.2 mm). The particles smaller than 0.25  $\mu\text{m}$  are  
20 collected by the net sampler.

#### The cascade impactor

- The size bands of a cascade impactor are influenced by the flow rate. At the flow rate  
25 20 l/min 50% particle retention efficiency aerodynamic diameters are shown in Table 1.

Table 1. 50% Particle Retention Efficiency aerodynamic diameters for May cascade impactor used in the prototype

30

- 7 -

Impactor stage number	1	2	3	4	5	6	7
50% Particle retention efficiency aerodynamic diameter, $\mu\text{m}$	20	8	4	2	1	0.5	0.25

The net sampler

- 5 There are two options shown as examples:
- (i) the basic configuration of the net sampler with 4 size sections and
  - (ii) 8-section net sampler.

10 At the flow rate 20 l/min maximal collection efficiency aerodynamic diameters for the basic configuration of the net sampler are shown in Table 2.

Table 2. Maximal collection efficiency aerodynamic diameters for the basic configuration of the net sampler

Net sampler section number	1	2	3	4
Maximal collection efficiency aerodynamic diameter, nm and ( $\mu\text{m}$ )	128 (0.128)	32 (0.032)	8 (0.008)	2 (0.002)

15

Maximal collection efficiency aerodynamic diameters (at the flow rate 20 l/min) for 8-section net sampler are shown in Table 3.

20 Table 3. Maximal collection efficiency aerodynamic diameters for 8-section net sampler

- 8 -

Net sampler section number	1	2	3	4	5	6	7	8
Maximal collection efficiency aerodynamic diameter, nm	128	64	32	16	8	4	2	1

The deposits on nets can be analysed separately. The size distribution of an aerosol is determined from chemical analysis or gravimetric measurements.

5

- 9 -

## Claims

1. A particle collector for collecting and sampling particles in a fluid which comprises sequentially (i) an inlet (ii) a first collector adapted to collect larger particles and (iii)  
5 a second collector adapted to collect smaller particles comprising a chamber in which there is at least one net or another material containing fibres placed across the chamber and a flows means able to sustain a flow of fluid sequentially through the inlet, first collector and second collector.
- 10 2. A particle collector as claimed in claim 1, in which there is a humidity control unit incorporated between the inlet and the large particle collector.
3. A particle collector as claimed in claim 2 in which the humidity control unit comprises a heater and a humidity sensor.
- 15 4. A particle collector as claimed in any one of claims 1 to 3 in which the first collector is a cascade impactor.
5. A particle collector as claimed in claim 4 in which a plurality of the cascade  
20 impactors is used in a sequence.
6. A particle collector as claimed in any one of claims 1 to 3 in which the first collector is a sedimentation unit.
- 25 7. A particle collector as claimed in any one of claims 1 to 3 in which the first collector is a cyclone.
8. A particle collector as claimed in any one of claims 1 to 3 in which the first  
30 collector is an array of a plurality of cyclones.

- 10 -

9. A particle collector as claimed in any one of claims 1 to 3 in which the first collector is a multi stage sedimentation unit.
10. A particle collector as claimed in any one of the preceding claims in which the net sampler contains a plurality of nets with different mesh openings.
11. A particle collector as claimed in any one of the preceding claims in which there is a saturator located upstream of the first collector.
12. A particle collector as claimed in any one of the preceding claims in which the fluid is dragged through the collector by a higher pressure generating means.
13. A particle collector as claimed in any one of the preceding claims in which there are a plurality of net samplers operating under different flow-rates.
14. A particle collector as claimed in any one of the preceding claims in which there are an optical particle counter, a dust monitor, nephelometer, aethelometer or a condensation particle counter are employed to obtain particle size distributions without chemical or gravimetric analysis.
15. A particle collector as claimed in any one of the preceding claims in combination with an ionisation unit and a mobility selective element.
16. A particle collector as claimed in claim 15 in which there an aerosol neutraliser placed between the mobility selective element and the net sampler.
17. A method for selective deposition of suspended particles from a fluid which method comprises passing the fluid sequentially over a first collector adapted to collect larger particles and then over a second collector adapted to collect smaller

- 11 -

particles, which second collector comprises a chamber in which there is at least one net or another material containing fibres placed across the chamber.

18. A method as claimed in claim 17 in which the first collector is a cascade  
5 impactor.

19. A method as claimed in claim 18 in which the cascade impactor has a plurality of stages.

10 20. A method as claimed in claim 17 in which the first collector is a sedimentation unit.

21. A method as claimed in claim 17 in which the first collector is a cyclone.

15 22. A method as claimed in claim 17 in which the first collector is an array of a plurality of cyclones.

23. A method as claimed in claim 17 in which the first collector is a multi stage sedimentation unit.

20 24. A particle collector as claimed in any one of the preceding claims 17 to 23 in which the net sampler contains a plurality of nets with different mesh openings.

25 25. A method as claimed in any one of the preceding claims 17 to 24 in which there is a saturator located upstream of the first collector.

26. A method as claimed in any one of claims 17 to 25 in which the larger particles are ionised and deposited in an electric field.

- 12 -

27. A method as claimed in claim 26 in which the charge on the particles is reduced by a neutralisation unit placed between the first collector and the second collector.

28. A particle collector substantially as herein before described with reference to and  
5 as shown in the accompanying drawings 2, 3 and 4.

29. A method for selective deposition of suspended particles from a fluid substantially as herein before described with reference to and as shown in the accompanying drawings 2, 3 and 4.

10

30. A particle collector as claimed in claim 13 in which two or more net samplers are assembled in parallel or sequentially.

31. A particle collector as claimed in claim 13 and 30 in which one or several net  
15 collectors are employed to collect large particles.

- 13 -

### Abstract

5 A Particle collector and sampler for use with aerosols has a first collector for larger particles and a second collector which is a net collector for smaller particles.

1/2

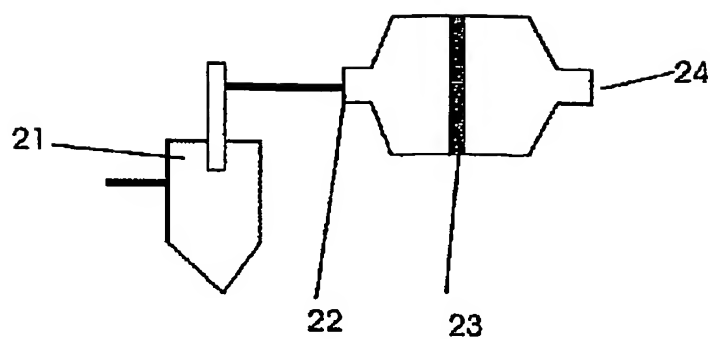


Fig. 1

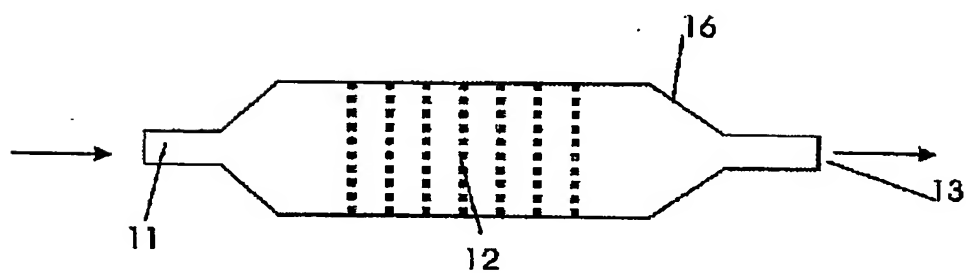


Fig. 2

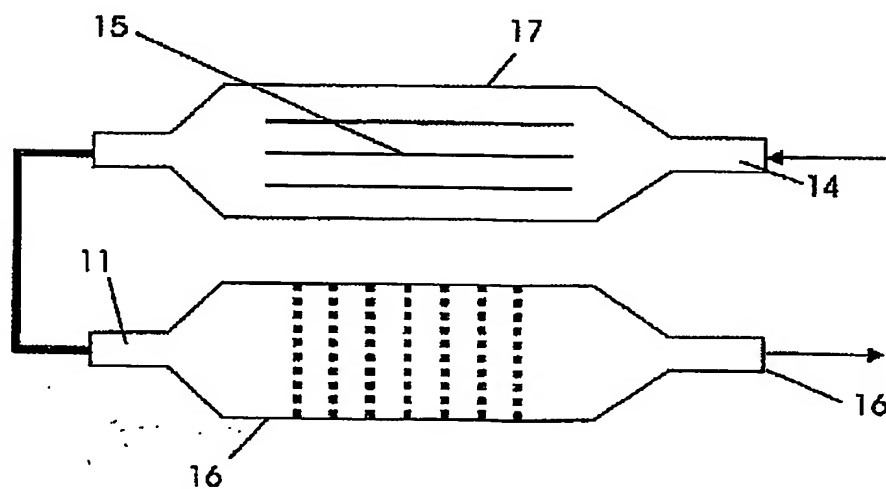


Fig. 3

2/2

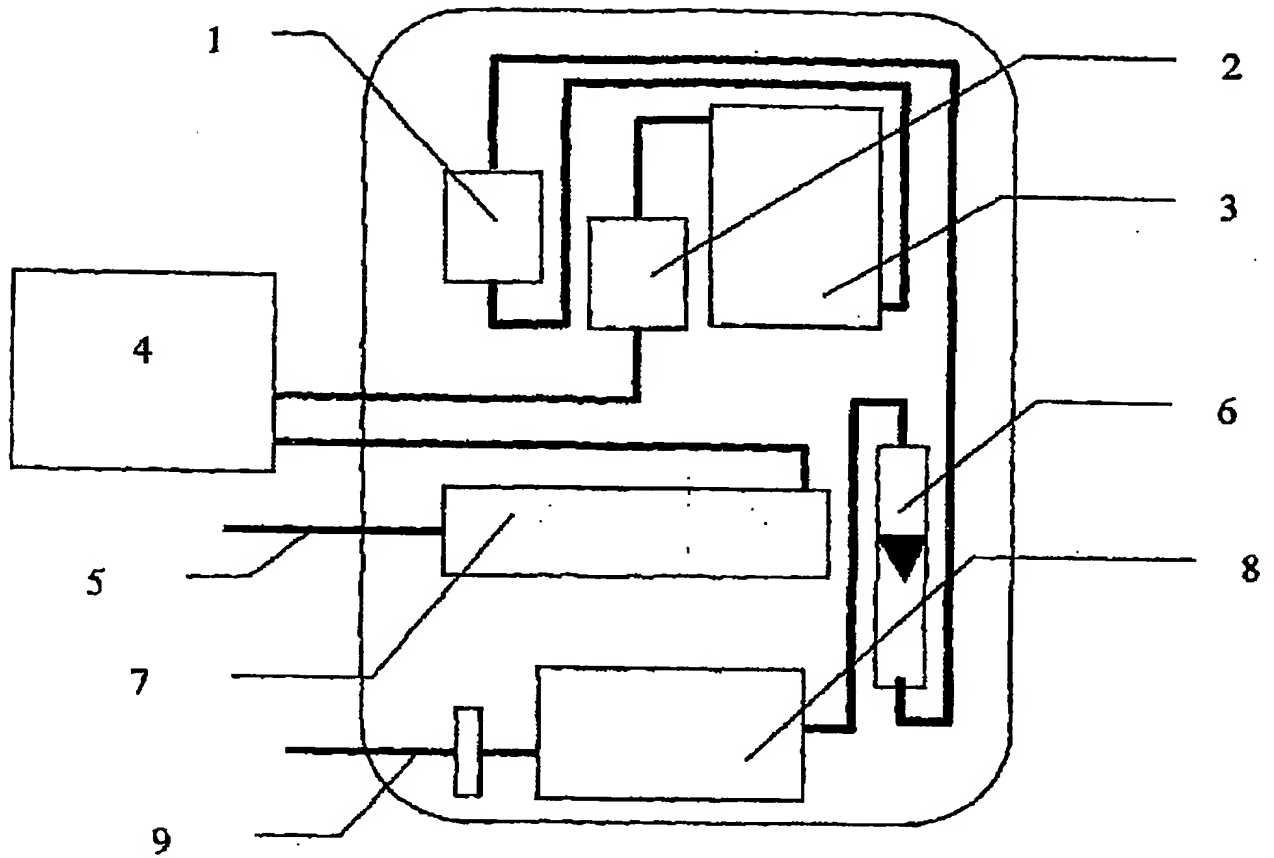


Fig. 4

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☒ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**